

**PATENT COOPERATION TREATY**  
**PCT**  
**INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY**  
(Chapter II of the Patent Cooperation Treaty)  
(PCT Article 36 and Rule 70)

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Applicant's or agent's file reference A*/I2R-P032WO	<b>FOR FURTHER ACTION</b> See Form PCT/IPEA/416	
International application No. PCT/SG2005/000014	International filing date (day/month/year) 20 January 2005	Priority date (day/month/year) 26 January 2004
International Patent Classification (IPC) or national classification and IPC  Int. Cl.  <i>H01Q 1/52</i> (2006.01) <i>H01Q 1/36</i> (2006.01) <i>H01Q 1/38</i> (2006.01)		
Applicant AGENCY FOR SCIENCE, TECHNOLOGY AND RESEARCH et al		

1. This report is the international preliminary examination report, established by this International Preliminary Examining Authority under Article 35 and transmitted to the applicant according to Article 36.
2. This REPORT consists of a total of 3 sheets, including this cover sheet.
3. This report is also accompanied by ANNEXES, comprising:
  - a. ☒ (sent to the applicant and to the International Bureau) a total of 4 sheets, as follows:
    - ☒ sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications authorized by this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions).
    - ☐ sheets which supersede earlier sheets, but which this Authority considers contain an amendment that goes beyond the disclosure in the international application as filed, as indicated in item 4 of Box No. I and the Supplemental Box.
  - b. ☐ (sent to the International Bureau only) a total of (indicate type and number of electronic carrier(s)) , containing a sequence listing and/or table related thereto, in electronic form only, as indicated in the Supplemental Box Relating to Sequence Listing (see Section 802 of the Administrative Instructions).
4. This report contains indications relating to the following items:

<input checked="" type="checkbox"/> Box No. I	Basis of the report
<input type="checkbox"/> Box No. II	Priority
<input type="checkbox"/> Box No. III	Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
<input type="checkbox"/> Box No. IV	Lack of unity of invention
<input checked="" type="checkbox"/> Box No. V	Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
<input type="checkbox"/> Box No. VI	Certain documents cited
<input type="checkbox"/> Box No. VII	Certain defects in the international application
<input type="checkbox"/> Box No. VIII	Certain observations on the international application

Date of submission of the demand 25 November 2005	Date of completion of this report 06 January 2006
Name and mailing address of the IPEA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaustrialia.gov.au Facsimile No. (02) 6285 3929	Authorized Officer  <b>DEREK BARNES</b> Telephone No. (02) 6283 2198

**Box No. I Basis of the report**1. With regard to the **language**, this report is based on:

- ☒ The international application in the language in which it was filed
- ☐ A translation of the international application into \_\_\_\_\_, which is the language of a translation furnished for the purposes of:
- ☐ international search (under Rules 12.3(a) and 23.1 (b))
  - ☐ publication of the international application (under Rule 12.4(a))
  - ☐ international preliminary examination (Rules 55.2(a) and/or 55.3(a))

2. With regard to the **elements** of the international application, this report is based on (*replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report*):

- ☐ the international application as originally filed/furnished
- ☒ the description:
- pages **1, 3, 4, 6-8** as originally filed/furnished
  - pages\* **2, 5** received by this Authority on **25 November 2005** with the letter of the same date
  - pages\* received by this Authority on with the letter of
- ☒ the claims:
- pages **11** as originally filed/furnished
  - pages\* as amended (together with any statement) under Article 19
  - pages\* **9, 10** received by this Authority on **25 November 2005** with the letter of the same date
  - pages\* received by this Authority on with the letter of
- ☒ the drawings:
- pages **1/3-3/3** as originally filed/furnished
  - pages\* received by this Authority on with the letter of
  - pages\* received by this Authority on with the letter of
- ☐ a sequence listing and/or any related table(s) - see Supplemental Box Relating to Sequence Listing.

3. ☐ The amendments have resulted in the cancellation of:

- ☐ the description, pages
- ☐ the claims, Nos.
- ☐ the drawings, sheets/figs
- ☐ the sequence listing (*specify*):
- ☐ any table(s) related to the sequence listing (*specify*):

4. ☐ This report has been established as if (some of) the amendments annexed to this report and listed below had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).

- ☐ the description, pages
- ☐ the claims, Nos.
- ☐ the drawings, sheets/figs
- ☐ the sequence listing (*specify*):
- ☐ any table(s) related to the sequence listing (*specify*):

\* If item 4 applies, some or all of those sheets may be marked "superseded."

**Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement****1. Statement**

Novelty (N)	Claims 1-16	YES
	Claims nil	NO
Inventive step (IS)	Claims 1-16	YES
	Claims nil	NO
Industrial applicability (IA)	Claims 1-16	YES
	Claims nil	NO

**2. Citations and explanations (Rule 70.7)****NOVELTY (N) and INVENTIVE STEP (IS)**

None of the documents listed in the International Search Report, alone or in obvious combination, disclose the features defined in independent claims 1 and 9 of the amended specification. Therefore claims 1 and 9 and dependent claims 2-8 and 10-16 are novel and have an inventive step.

Specifically the prior art documents do not disclose an antenna array including first array elements and second array elements each element having a radiator suspended from a ground plane, where the ground plane of the first array element is disposed on a first tier and the ground plane of the second array element is disposed on a second tier, wherein the ground planes of the first and second array elements are adjacent to and displaced from each other so that an at least two-tiered unitary ground conductor is formed.

Summary

Embodiments of the invention are disclosed hereinafter for reducing the lateral size of an antenna array with reduced or weak mutual coupling by using a multi-tiered configuration. In particular, a common ground conductor, typically planar and single-tiered in a conventional antenna array, is multi-tiered by folding or corrugation to reduce the lateral spacing between plate array elements while maintaining the inter-element spacing.

10 In accordance with one aspect of the invention, there is disclosed an antenna array having a plurality of array elements, the antenna array comprising a first array element having a first suspended radiator and a first ground conductor, the first suspended radiator being displaced from the first ground conductor. The antenna also comprises a second array element being adjacent to the first array element, the second  
15 array element having a second suspended radiator and a second ground conductor, wherein the second suspended radiator is displaced from the second ground conductor. In the antenna array the first ground conductor is adjacent to and displaced from the second ground conductor and the first ground conductor is disposed on a first tier and the second ground conductor is disposed on a second tier to form an at least two-tiered unitary ground conductor.  
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In accordance with another aspect of the invention, there is disclosed a method for configuring an antenna array having a plurality of array elements, the method comprising the steps of providing a first array element having a first suspended  
25 radiator and a first ground conductor, the first suspended radiator being displaced from the first ground conductor, and providing a second array element as adjacent to the first array element, the second array element having a second suspended radiator and a second ground conductor, wherein the second suspended radiator is displaced from the second ground conductor. The method also comprises the steps of disposing  
30 the first ground conductor adjacent to and displaced from the second ground conductor, and disposing the first ground conductor on a first tier and the second ground conductor on a second tier to form an at least two-tiered unitary ground conductor.

same plane and form a lower tier or level with the corresponding plate array elements 114.

Each plate array element 114 comprises a suspended plate radiator and a  
5 corresponding ground patch, the ground patch being plate-like and part of the common ground conductor 116. The suspended plate radiator is fed with signals through conventional feeding means.

Since the common ground conductor 116 is corrugated, inter-element spacing D2 is  
10 greater than lateral spacing L2 in relation to two nearest adjacent plate array elements 114. By having the inter-element spacing D2 being substantially equivalent to the inter-element spacing D1 in the conventional rectangular plate antenna array 102, mutual coupling between the plate array elements 114 in this case is not worsened or increased. This is true even though the lateral spacing L2 is smaller than the lateral  
15 spacing L1 in the conventional rectangular plate antenna array 102.

The plate antenna array 122 as shown in Fig 1(c) includes plate array elements 124 arranged in a single row along the length of the rectangular plate antenna array 122 and has a symmetrical structure. The rectangular plate antenna array 122 also  
20 includes a rectangular and two-tiered common ground conductor 126 folded or corrugated longitudinally into alternating ridges 128 and grooves 129A and 129B, the grooves 129A and 129B not being of uniform widths. Specifically as shown in Fig. 1(c), in the middle of the rectangular plate antenna array 122 the central groove 129A is wider than the side grooves 129B as in the central groove 129A two plate array  
25 elements 124 are disposed. The ridges 128 are disposed on a same plane and form a higher tier or level with the corresponding plate array elements 124 while the grooves 129A and 129B are also disposed on a same plane and form a lower tier or level with the corresponding plate array elements 124.

Each plate array element 124 comprises a suspended plate radiator and a  
30 corresponding ground patch, the ground patch being plate-like and forming part of the common ground conductor 126. The suspended plate radiator is fed with signals through conventional feeding means.

Claims

1. An antenna array having a plurality of array elements, the antenna array comprising:

5 a first array element having a first suspended radiator and a first ground conductor, the first suspended radiator being displaced from the first ground conductor; and

a second array element being adjacent to the first array element, the second array element having a second suspended radiator and a second ground conductor, wherein the second suspended radiator is displaced from the second ground conductor,

10 wherein the first ground conductor is adjacent to and displaced from the second ground conductor and the first ground conductor is disposed on a first tier and the second ground conductor is disposed on a second tier to form an at least two-tiered unitary ground conductor.

15 2. The antenna array as in claim 1, wherein the first array element is immediately adjacent to the second array element.

3. The antenna array as in claim 1, wherein the first ground conductor is continuous with the second ground conductor.

4. The antenna array as in claim 1, wherein the inter-element spacing between the first array element and the second array element is greater than the lateral spacing therebetween.

25 5. The antenna array as in claim 1, wherein the antenna array is a plate antenna array.

6. The antenna array as in claim 5, wherein each of the first and second array elements is a plate array element.

30 7. The antenna array as in claim 6, wherein each of the first and second ground conductors is a ground patch.

8. The antenna array as in claim 7, wherein the first ground patch is continuous with the second ground patch.

5 9. A method for configuring an antenna array having a plurality of array elements, the method comprising the steps of:

providing a first array element having a first suspended radiator and a first ground conductor, the first suspended radiator being displaced from the first ground conductor;

10 providing a second array element as adjacent to the first array element, the second array element having a second suspended radiator and a second ground conductor, wherein the second suspended radiator is displaced from the second ground conductor;

disposing the first ground conductor adjacent to and displaced from the second ground conductor; and

15 disposing the first ground conductor on a first tier and the second ground conductor on a second tier to form an at least two-tiered unitary ground conductor.

10. The method as in claim 9, wherein the step of disposing the first ground conductor adjacent to and displaced from the second conductor includes disposing the first array element immediately adjacent to the second array element.

11. The method as in claim 9, further comprising the step of providing the first ground conductor as continuous with the second ground conductor.

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12. The method as in claim 9, further comprising the step of providing the inter-element spacing between the first array element and the second array element as greater than the lateral spacing therebetween.

30 13. The method as in claim 9, further comprising the step of providing the antenna array as a plate antenna array.